Ion Microprobe Sensitivities and their Application to Multielement Analysis of LDEF Impact Residues; G.Lange[2], S.Eigner[2], E.Igenbergs[2], E.K.Jessberger[1], H. Kuczera[2], D. Maas[1], S. Sutton[3], U. Weishaupt[2], E. Zinner[3]; [1] Max-Planck-Institut für Kernphysik,Heidelberg,FRG; [2] Technische Universität München,FRG; [3] McDonnell Center for the Space Sciences,St.Louis,Mo.,USA;

The capture cell experiment onboard the LDEF-satellite [1] is designed to enable the study of the elemental and isotopic composition and the physical properties of interplanetary dust particles, destructively collected in 500 km altitude for a period of ~29 months. Each cell consists of a Ge-target plate covered in 0.2mm distance by a 2.5 μm thick Mylar foil coated at the Ge-facing side with a 1300 Å Ta-layer to facilitate SIMS analyses of reflected projectile material which is deposited as a thin cover of particle residues on the Ta-layer. Typically 10^{13} atoms of the projectile are spread over a 0.1 mm^2 area around the penetration hole. The present report is on our ongoing calibration experiments to investigate the relationship of post-impact data obtained by microscope and SIMS to pre-impact properties (mass, velocity, density) and chemical and isotopic composition of the dust grain. Results from previous studies, including isotope measurements, have already been reported [2,3]. Here we focus on quantitative multielement SIMS analysis.

Two approaches have been chosen to determine the SIMS sensitivities for a number of elements: (A) Ion-implantation of 13 cosmochemically relevant elements into Ta with 2 keV/nucleon in doses from 10^{13} to 5×10^{14} ions/cm^2 and subsequent SIMS analysis of the irradiated samples. It turned out that the determination of the implanted ion dose is critical. (B) Comparison of the results from electron microprobe and ion microprobe measurements at high mass resolution of two different homogeneous glass standards (Lunar Analog Glass [LAG] and Solar Glass NTR-1 [SG]). Glass was chosen because we expect that projectile residues always are glassy, due to melting during impact. The Si-normalized sensitivities obtained by (A) and (B) are shown in Fig. 1 and are compared to literature values. Sensitivities derived by method (B) with LAG and SG practically are the same and lie well within the wide ranges determined by others [4-6].

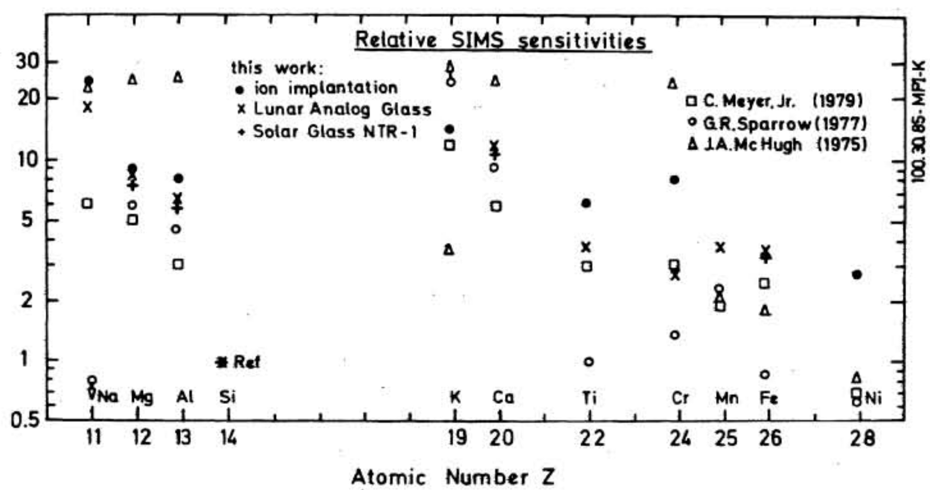

Fig.1: SIMS sensitivities for positive secondary ions (O_2^+ primary beam) relative to ^{28}Si

Glass-projectile residues of experimental high velocity impacts ($10^{-9}g \leq m \leq 3 \times 10^{-8}g$; 5.1 km/sec $\leq v \leq$ 8.1 km/sec) in the capture cell detectors have been analyzed by SIMS (O_2^+-beam,~1nA) on both, the Ta-coated side of the plastic-foil ("deposit", splashes of reflected projectile and target material around the penetration hole) and the Ge-target ("spider web", a melt of germanium and projectile material).

The SIMS ion signals for the major projectile elements obtained from $40 \times 40\mu m$ spots along $600\mu m$ traverses over each penetration hole and the corresponding spider web below, respectively, show distinct enhancements of the ion signals around the impact location (Fig.2). After integrating these signals for each traverse from 14 deposits and 12 spider webs, the average ^{24}Mg normalized intensities are compared to the corresponding intensities obtained from the glass standards (Fig.3). Obviously the analyzed elements are fractionated during the impact. Relative to Mg, the elements Al, Ca and Ti are enriched while Si and Fe are depleted. Fractionation effects are more pronounced in target residues (spider webs) than in deposits. Taking the melting temperature as a measure of volatility, fractionation clearly is related to volatility. No dependence from projectile composition became apparent.

The described calibration experiments provided SIMS sensitivities and fractionation factors which are prerequisits to enable the full SIMS analysis of interplanetary dust particles collected with capture cells onboard LDEF.

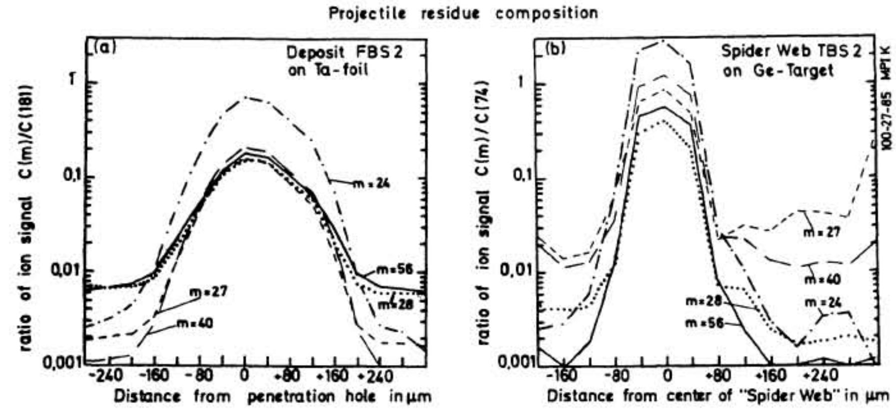

Fig.2: Spatial distribution of the ion signals, normalized to ^{181}Ta- and ^{74}Ge-intensities, respectively, across a deposit around a penetration hole (a) and a 'spider web' on the Ge-target (b)

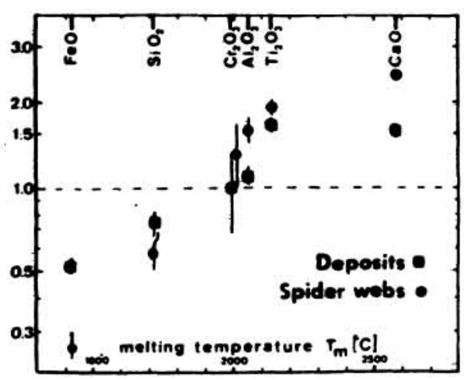

Fig.3: Impact fractionation of six elements relative to Mg. The elements are ordered according to the melting temperature of their oxide (top scale).

References: [1]LDEF, NASA SP-473 (1984); [2]E.K. Jessberger et al.,Lunar Planet. Sci. Conf.XV (1985) 400 [3]H. Fechtig et al., in "Properties and Interactions of Interplanetary Dust" (R.H.Giese and P.Lamy, eds.) Reidel (1985) 121; [4]C. Meyer Jr. in "SIMS II" (1979) 67; [5]J.A. McHugh, in "Methods of Surface Analysis" (1975) 223; [6]G.R. Sparrow, 25th Annual Conference on Mass Spectromety and allied Topics (1977);